Algal Growth Optimization Using Advanced Lighting Techniques

Algae have attracted significant attention for their ability to produce products such as proteins, lipids (omega 3, 6 and 9), nutraceuticals, pharmaceuticals and dyes. Being a photosynthetic organism, it relies on light for energy, and thus, growth. The prevailing choice of light source at cultivation sites is sunlight (whose spectrum algae are adapted to) since it is free. The main drawback of using this source is that it is not consistent: e.g., there are less hours of sunlight in spring compared to summer, and changing weather conditions can impact light intensity at much shorter timescales. This drawback can be overcome by using supplemental artificial lighting or by using artificial lighting only; options that can additionally provide new possibilities, such as allowing for a tailored spectrum to boost the production of certain compounds (e.g., using blue light to boost pigment production[1]). However, such a practice is often financially unfeasible due to electricity costs. Methods to optimize growth per unit of electricity are therefore of great interest to drive down costs. One promising method involves fluctuating the light intensity at specific frequencies to optimally drive photosynthetic reactions, but studies have been conflicting[2,3].

This project aims to rigorously evaluate the use of fluctuating light for boosting the growth rate of algae. It will involve following growth rate through the simultaneous measurement of chlorophyll fluorescence and O_2 while exposing algae cells to different lighting conditions; varying average light intensity, fluctuation frequency/frequencies (sinusoidal/multi-sinusoidal) and amplitude; to select the most optimal. At the end, it is envisioned that the project will deliver an experimental setup which can perform the lengthy experiments in a parallelized manner (with each lighting condition being simultaneously applied to samples in a well within a microwell plate). Then, the experiments performed will deliver lighting conditions which optimize growth rate per unit of electricity.

We are seeking a student who is interested in developing hardware and software for biological experiments. The student will have the opportunity to work with optical components (lenses and filters), optomechanics (some 3D designed and printed), electronics (cameras, point detectors, digital micromirror devices, motors, Arduinos, etc.) and write software to pilot the developed hardware (C++ in the case of the Arduinos, but mainly python). The student will also gain experience in working with algae, for which they will need to interact with biologists, and finally data processing of their results in python.

Please contact Ludovic Jullien (PI: Ludovic.Jullien@ens.psl.eu) or Ian Coghill (Postdoc: Ian.Coghill@ens.psl.eu) for further information.

1. Katsuda, T., Lababpour, A., Shimahara, K. & Katoh, S. Astaxanthin production by Haematococcus pluvialis under illumination with LEDs. Enzyme and Microbial Technology **35**, 81–86 (2004).
2. Schulze, P. S. C. et al. Flashing light does not improve photosynthetic performance and growth of green microalgae. Bioresource Technology Reports **9**, 100367 (2020).
3. Grobbelaar, J. U., Nedbal, L. & Tichý, V. Influence of high frequency light/dark fluctuations on photosynthetic characteristics of microalgae photoacclimated to different light intensities and implications for mass algal cultivation. J Appl Phycol **8**, 335–343 (1996).